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DEPARTMENT OF AGRICULTURE.
CHEMICAL DIVISION.

BULLETIN No. 2.

DIFFUSION.

ITS APPLICATION TO SUGAR-CANE,

AND

RECORD OF EXPERIMENTS WITH SORGHUM IN 1883.

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CHEMIST.

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DEPARTMENT OF AGRICULTURE,
CHEMICAL DIVISION,
Washington, January 1, 1884.

SIR: I submit herewith the results of my observations on the process of *diffusion*, with a *résumé* of the experiments made with this process on sorghum cane by this division during the past year.

Respectfully,

H. W. WILEY,
Chemist.

HON. GEO. B. LORING,
Commissioner of Agriculture, Washington, D. C.

THE PROCESS OF DIFFUSION APPLIED TO SORGHUM CANE; WITH HISTORICAL SKETCH.

Manufacturers have long recognized the fact that large quantities of sugar are lost in the bagasse. In single milling, *i. e.*, passing through one three-roll mill, the per cent. of loss has been variously estimated at 25 for a minimum and 60 for a maximum.

In Louisiana and the tropical islands the most conflicting accounts are given of the percentage of juice expressed. Tropical canes appear to contain about 90 per cent. of juice, and of this an average of probably 55 per cent. is expressed, or about half the weight of the cane. When double milling is employed, *i. e.*, five-roll mills, or two sets of three rolls each, a larger percentage of juice is secured.

Still a greater percentage of the saccharine matter is extracted if the partially pressed canes, after leaving the first set of rolls, are saturated with steam or hot water before passing the second.*

In sorghum cane I am able to give more exact data.

A mean of fifteen experiments, which I made in 1882, with single milling, gave a weight of juice equal to 65 per cent. of the stripped cane. In nearly 300 tons of unstripped amber canes, ground during the season of 1883, at Washington, the weight of the expressed juice was 41.7 per cent. that of the cane.

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* For further data concerning loss of sugar in bagasse, see the letter of Mr. R. Sieg, p. 18.

In 48 tons of unstripped amber canes ground during the past season at West Point, Ind., I found the weight of the juice to be 50 per cent. that of the cane.

In over 6,000 tons of Amber and Orange canes ground at Rio Grande, N. J., during the campaign of 1883 the per centage of juice expressed (double milling) varied from 40 to 55. At Champaign, Ill., 4,660 tons (half stripped) gave a yield of about 60 per cent. juice. Double milling was employed.

After a careful study of the data which I have been able to accumulate, I am of the opinion that not less than 40 per cent. of the total sugar present in the cane is lost in the bagasse. This is a waste far greater than true economy can permit.

I shall endeavor to show in this report the nature of the cane as related to juice extraction, and the nature of the process of diffusion. I shall also briefly allude to the development of the process of diffusion and its application to the sugar-beet, and to the tropical canes in Louisiana and the islands. Finally, I shall give a review of the experiments I have made with this process applied to sorghum, and show its relation to the sugar industry of the future.

SORGHUM CANE; ITS CHARACTERISTICS AS RELATED TO EXTRACTION OF THE SUGAR.

WATER.

The quantity of water contained in sorghum cane varies with the character of the cane and the kind of season in which it is grown.

I will give the results of experiments with Link's Hybrid cane. This cane contained nearly 10 per cent. sucrose in its juice. To determine the water, the canes are cut into diagonal slices one-eighth inch thick. These are then placed in a thin layer in a copper chamber heated by steam to a uniform temperature of 100° C. (212° F.).

After about fourteen to eighteen hours the chips suffer no further material loss of weight. They are then removed and their weight taken. Following are the results:

DRIED FOURTEEN HOURS AT 100°.

	Per cent. moisture.
No. 1	76.38
No. 2	76.96
No. 3	76.31
No. 4	76.66
No. 5	78.18
No. 6	78.38
No. 7	77.94
No. 8	78.05

DRIED SEVENTEEN HOURS AT 100°.

	Per cent. moisture.
No. 9	77.62
No 10	77.64
No. 11	77.21
No. 12	77.54
No. 13	77.41
No. 14	77.23
No. 15	77.42
No. 16	77.30
No. 17	77.62
No. 18	76.96
Mean	77.38

From this table we learn that the water in a cane whose juice yields 12.5 per cent. total sugars is about 77 per cent. of the whole weight. An increase or decrease of sugar would probably affect the water more than any other constituent of the cane.

As a practical rule, therefore, we may safely assume that the per cent. of water in a sorghum cane is 77, plus or minus the difference between total sugars of expressed juice and 12.5.

For instance, when total sugars equal 15 per cent. the water would be 77 — (15 — 12.5) = 74.5.

If total sugars are only 10 per cent. the water will be 77 + (12.5 — 10) = 79.5.

I made an experiment to determine the water in a Louisiana cane, the juice of which had 15.5 per cent. sucrose and 1.25 of other sugars; total, 16.75. It gave moisture 72 per cent.; calculated from foregoing rule, 72.75.

CELLULOSE.

The sugar in the cane is contained in cellular tissue, the cells being grouped together like a honeycomb.

The sugar is held in a state of solution in these cells by the water. The idea that sugar exists in the cane in a crystalline form is contrary to all rules of chemical physics and accurate observation.

Cane sugar is completely soluble in about half its weight of water, and hence it could scarcely be crystallized in presence of six to seven times its weight.

The most remarkable instance of the crystallization of sugar in the cells of the sorghum cane on record is found in a book entitled "Sorghum and its Products," by F. L. Stewart, and printed by J. B. Lippincott & Co., Philadelphia, 1867. The crystals of sugar as there illustrated are nearly all triangular in shape, and belong to quite a different system from those of ordinary cane sugar. The language of the author describing these crystals is so interesting that I will quote it:

> An incontrovertible evidence of the presence of cane sugar in the juice of the sorghum is afforded in the fact that thin sections of the fresh stalk of the plant under the microscope exhibit the cells filled with innumerable minute crystals of pure white sugar, which by their form and other criteria are shown to be cane sugar only.

Scarcely a trace of any other substance is found in the cells. * * * The pithy part of the stalk throughout presents the same appearance as that given above. (Stewart. *op. cit.*, page 186.)

If the cells of sorghum contain nothing else except crystals of *pure white sugar*, it will be difficult to find storage room for the 77 per cent. of water which the stalks contain.

I emphasize this matter here, because this delusion is widespread, and the Patent Office is full of descriptions of processes based on the assumed existence of crystals in the cane. Even in the bulletin of the New Jersey agricultural station, where we have been accustomed to find so much that is scientific, valuable, and exact. I find this error meeting with some degree of approval. In No. XXX, page 5, are found the following lines:

> To explain this loss, it is necessary to assume that a considerable portion of the sugar is stored in the cane in a solid state, either as pure crystallized sugar or in some combination easily decomposed and dissolved in water.

In order to have a more accurate idea of the histology of the sorghum cell, I have asked Dr. Thomas Taylor, microscopist of the Department of Agriculture, to make a thorough investigation of this interesting subject. I furnished him with fresh samples of sorghum and Louisiana canes. The juice of the Louisiana cane contained 15.5 per cent. sucrose and 1.25 per cent. of other sugars. That of the sorghum cane contained nearly 10 per cent. of sucrose and 2.5 per cent. other sugars.

On receiving the canes he made thin sections of them by two methods; first, by the use of a freezing microtome; second, by securing the specimens in wax, omitting the freezing process. The practical results attained by both methods proved identical. Sections were made across the canes, and lengthwise, not exceeding the $\frac{1}{400}$ of an inch in thickness. These were examined first without any preparation, by simply placing them between two slips of glass, by which means crystals of sugar, if present, could be observed. In this way a solution of the crystals could not be effected since no solvent was added.

These sections were viewed by plain transmitted light, and by polarized light, with and without the aid of a selenite plate. In the sections of sugar cane thus tested, a few granules of starch were seen. These were readily stained blue by the use of the tincture of iodine and dilute sulphuric acid.

In all about 200 sections of these canes were examined, and no trace of cane sugar in crystallized form in the cell tissues of either variety of cane mentioned was discovered.

The results of the investigations show that the sugar exists neither in a crystalline state nor in "some combination easily decomposed or dissolved in water."

DISTRIBUTION OF THE SACCHARINE MATTER.

The aqueous solution of the sugars in the stalk is either (1) contained within the cells, or (2) infiltrated in the cellular substance. The object of milling is, therefore, twofold, (*a*) to break the cell structure and allow the liquids to escape, and (*b*) to press the cellular tissues and thus deprive them of their fluid contents.

Evidently the greater the pressure the more perfectly the dehydration of the pulp will be. This pulp, however (of the same nature of blotting paper), is exceedingly bibulous, and even after the liquids are forced out it will absorb them again as the pressure is removed.

Again, no amount of pressure is able to produce a perfectly dry mass, and thus it comes that a large portion of the juice is usually left in the bagasse.

A practical question arises here, viz: Has the juice which is left in the bagasse a proportion of sugar different from that which is expressed?

The answers to this question have been so different that I have subjected them to the test of a series of analyses.

December 10–13, inclusive, five lots of sorghum cane, preserved in a silo, were subjected to analysis.

JUICE.

The mean percentage of juice expressed was	64.11
Bagasse	35.89
Eleven analyses of these mill juices gave (mean) *sucrose*	9.31
Seven analyses (mean), *other sugars*	2.18
Total sugars (mean) in juice	11.49

CANES.

The canes were cut into thin slices. About 40 kilograms were used for each sample and the chips well mixed.

Sucrose (mean of eighteen analyses)	8.64
Other sugars (mean of eight analyses)	1.92
Total sugar in chips (mean)	10.56

BAGASSE.

The bagasse, immediately after milling, was run through the cane cutter, the chips well mixed and sampled for analysis.

Percentage of bagasse	35.89
Sucrose (mean of seventeen analyses)	6.17
Other sugars (mean of six analyses)	1.99
Total sugars in bagasse (mean)	8.16

From these analyses the following interesting facts appear:

(1.) The ratio of the sucrose in the chips to that in the juice is 8.64 : 9.31, or 100 kilograms of cane contain as much sucrose as 92.8 kilograms of juice.

(2.) The ratio of other sugars in the chips to those in the juice is 1.92:2.18, or 100 kilograms of cane contain as much uncrystallizable sugar as 88.1 kilograms juice.

(3.) The ratio of total sugar in the chips to that in the juice is 10.56 : 11.49, or 100 kilograms of cane contain the same amount of sugars as 91.9 kilograms of juice.

(4.) The mean of sucrose in the bagasse was 6.17, or 2.21 per cent. total weight of cane.

The total sucrose in the cane as determined by the sum of the analyses in the juice and bagasse was $9.31 \times .6411 + 2.21 = 8.18$ per cent.

(5.) The mean of uncrystallizable sugar in the bagasse was 1.99 or .71 per cent. of the weight of cane.

The total "other sugars" in the cane as determined by the analyses of the juice and bagasse were $2.18 \times .6411 + .71 = 2.11$.

(6.) Total sugars as determined by analysis of juice and bagasse were $8.18 + 2.11 = 10.29$ per cent.; as determined by analysis of chips 10.56. This is an agreement as close as could be expected from the difficulty of obtaining perfectly similar samples.

(7.) The bagasse obtained as above, as shown by numerous experiments, contains about 69 per cent. of water and materials soluble therein and 31 per cent. cellulose and insoluble substances. In other words, the bagasse has still about 69 per cent. of juice, or 24.74 per cent. of the weight of the cane.

(8.) The composition of the juice remaining in the bagasse can be calculated as follows: Per cent. of juice, calculated on weight of cane, remaining in bagasse $= 24.7$; per cent. of sucrose remaining in bagasse, 2.21 (weight of cane); per cent. of sucrose in juice remaining in bagasse $= 2.21 \div 24.7 \times 100 = 8.95$.

For "other sugars" we have the formula $.71 \div 24.7 \times 100 = 2.88$.

Therefore,

Total sugar in bagasse juice	11.83%
Total sugar in mill juice	11.49%

These two numbers are so nearly the same that the logical conclusion is that there can be no great difference between the juice expressed by the mill and that left in the bagasse.

In this series of experiments it is true that the percentage of sucrose in the mill juice appears to be slightly greater than in the bagasse juice. For example, the ratio of sucrose to other sugars in the mill juice is 9.31:2.18 or 4.27 : 1. In the bagasse juice, by analysis, it is 6.17 : 1.99, or 3.10 to 1, and by calculation 8.95 : 2.88, or 3.11 : 1.

CONCLUSIONS.

I am only sorry that I was not able during the past season to apply this method of investigation to other varieties of sorghum and also to Southern canes. If we adopt the motto, not always a wise one in science, *Ex pede, Herculem*, the following conclusions are justifiable:

(*a*) The saccharine matter in the cane is evenly distributed through the juices of the stalk.

(*b*) Hence the juice remaining in the bagasse has the same saccharine richness as that expressed by the mill.

(*c*) But in the few experiments made the sucrose appears to be slightly in excess in the mill juice, and (*d*) the uncrystallizable sugar in the juice remaining in the bagasse.

The conclusions (*c*) and (*d*) are given subject to modifications from a more extended series of observation.

In a very large number of analyses I have found no indication of the existence of the sugar in the cane in a solid state, nor in any form of combination which would indicate an inequality in its distribution in the cane juices.

THEORY OF DIFFUSION.

If a solution of a crystallizable substance be separated from pure water, or a solution of the same substance of a different density, by an animal or vegetable membrane, an interchange will take place between the two liquids until they are practically of the same composition. This principle is called *osmose*. In a vegetable cell containing sugar in solution the flow of water inward is called *endosmose*, and that of the sugar solution outward *exosmose*. The term *crystalloids* has been applied to those bodies tending to assume a crystalline shape, and *colloids* to those that have no tendency thereto.

Crystalloids are much more sensitive to osmosis than colloids, but possess this sensibility in different degrees. For example, solutions of metallic salts, such as those of potassium, respond to the osmotic force more readily than those of sugar. This difference is utilized in the construction of "osmogenes," apparatus, which are used in the beet-sugar industry to separate the potassium and other mineral salts from the sugar.

If vegetable substances containing sugar are cut into thin slices and exposed to the action of water, the sugar will pass out through the cell walls, and water flow in, until there is an even distribution of the sugar throughout the whole. If the external water is now drawn off, and a fresh portion supplied, the same phenomenon will be repeated. When this has been done eight or ten times the amount of sugar left in the cell is so small that for practical purposes it may be neglected.

MATHEMATICAL THEORY.*

Let n = number of cells in the battery.

a = volume of juice contained in the chips forming a charge for a single cell.

b = volume of liquid transferred from cell to cell.

g_0 = specific gravity of undiluted cane juice.

g_n = specific gravity of liquid in the rejected chips.

g_1 = specific gravity of diffusion juice.

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* I desire to thank Professor Harkness of the Naval Observatory for this formula.

Then

$$g_n = g_1 - (g_0 - g_1)\left\{\left(\frac{a}{b}\right) + \left(\frac{a}{b}\right)^2 + \left(\frac{a}{b}\right)^3 \cdots\cdots \left(\frac{a}{b}\right)^n \right\}$$

The specific gravity of the liquid remaining in the cane chips in each cell when the liquid from the adjoining cell enters, and also the specific gravity of the liquid entering and leaving each cell, may then be designated as follows:

No. of cell.	SPECIFIC GRAVITY OF LIQUID.		
	In cane chips.	Entering cell.	Leaving cell.
1	g_0	g_2	g_1
2	g_1	g_3	g_2
3	g_2	g_4	g_3
4	g_3	g_5	g_4
&c.	&c.	&c.	&c.
n	g_{n-1}	g_{n+1}	g_n

As the liquid entering any cell soon mixes with that contained in the chips therein, and reduces the whole volume of fluid to a uniform specific gravity, we have

$$g_1 = \frac{ag_0 + bg_2}{a + b} \qquad (1)$$

Whence

$$g_2 = g_1 - \frac{a}{b}(g_0 - g_1) \qquad (2)$$

and in general

$$g_n = g_{n-1} - \frac{a}{b}(g_{n-2} - g_{n-1}) \qquad (3)$$

$$g_{n-1} = g_{n-2} - \frac{a}{b}(g_{n-3} - g_{n-2}) \qquad (4)$$

$$g_{n-2} = g_{n-3} - \frac{a}{b}(g_{n-4} - g_{n-3}) \qquad (5)$$

Substituting in (3) the values of g_{n-1} and g_{n-2} from (4) and (5), we get

$$g_n = g_{n-3} - (g_{n-4} - g_{n-3})\left\{\left(\frac{a}{b}\right) + \left(\frac{a}{b}\right)^2 + \left(\frac{a}{b}\right)^3\right\} \qquad (6)$$

The law governing the formation of the series is now evident, and its complete expression is

$$g_n = g_1 - (g_0 - g_1)\left\{\left(\frac{a}{b}\right) + \left(\frac{a}{b}\right)^2 + \left(\frac{a}{b}\right)^3 \cdots \left(\frac{a}{b}\right)^n\right\} \qquad (7)$$

This formula gives the relations between the specific gravities of the cane juice, the diffusion juice taken from the first cell, and the juice remaining in the chips when they are rejected; and it shows that so long as $g_0 - g_1$ is approximately constant, the smaller b is made with respect to

a, the more efficiently the battery will work. If b is greater than a, the first cell will do most work, and each succeeding cell will do less and less; if b is equal to a, all the cells will work alike; and if b is less than a, the first cell will do least work, and each succeeding cell will do more and more. When it is remembered that the work of the first cell constantly increases as b diminishes, the extreme importance of using the least possible quantity of water in the cells becomes evident. Indeed the amount of water employed, and the value of $g_0 - g_1$, are the factors which determine the number of cells requisite to reduce the specific gravity of the liquid in the rejected chips to any given standard. In practice the number of cells employed has varied from six to eleven.

HISTORICAL.

The German chemist Margraff, who first detected the presence of sugar in the beet in 1747, attempted its extraction by a process similar to diffusion.

Dombasle, in 1842, made the first attempt to apply the principle of osmose to the extraction of sugar from vegetable cells, on a commercial scale.

Dombasle was led to believe from his experiments that the process of desaccharization could not be successfully carried on in the living cell (*i. e.*, fresh vegetable cells), but that it was first necessary to dry them or heat them to 100° in order to destroy the life of the cell. This process he called "mortification."

On the beet roots, however, attempts to apply diffusion at a high temperature resulted in obtaining a viscous juice, with a great tendency to fermentation, and opposing considerable difficulties to crystallization. This trouble comes from the fact that water near the boiling point transforms the insoluble *pectose*, which exists in the beet in considerable quantities, into soluble *pectine*. It was this substance that exerted such an injurious influence on the juices.

From the researches of Dubrunfaut on "*osmose* and its employment in industry," the early workers of diffusion concluded that the exhaustion of the pulp was more easy, as its division was more minute; that the natural adherence of the cells, as well as the gases contained in the intercellular spaces, prevented the access of the diffusion fluid and resisted the double current of osmotic force.

It is true that after a certain time this force will overcome these obstacles without the temperature being raised high enough to produce mortification; but in this case secondary effects are produced, such as viscous and lactic fermentation, which interfere with the progress of diffusion.*

Under these supposed disadvantages the process of diffusion languished, except when it was used to prepare the juice for the distilleries.

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* La Diffusion de M. Jules Robert.

The problem was not solved until Robert, in 1864, by a series of experiments on a large scale at Seelowitz, in Moravia, proved that the former ideas were incorrect, and that the process of diffusion could be carried on at a temperature not above 40°, producing a juice of remarkable purity and quite free from pectine.

To show the superiority of the juice obtained by this method over that from the press, I append the following analyses:

No. I.

	Press juice.	Diffusion juice.
Total solids	13.936	10.236
Of which, sugar	11.25	8.41
Ash	.603	.449
Organic matter	2.083	1.377
Then in 100 of sugar—		
Ash	5.36	5.339
Organic matter	18.516	16.373
Sum	23.876	21.712
No. II.		
Total solids	15.521	13.986
Of which, sugar	12.41	11.58
Potash and soda salts	.458	.441
Lime and magnesia salts	.187	.191
Nitrogenous organic matter	1.418	1.791
Non-nitrogenous organic matter	1.048	.983
Or for 100 parts of sugar—		
Potash, &c., salts	3.69	3.808
Lime, &c., salts	1.507	1.649
Nitrogenous, &c	11.426	6.830
Non-nitrogenous, &c	8.445	8.488
Sum	25.068	20.775

The success of the Robert's diffusion was so pronounced that the process became rapidly adopted among sugar fabricants, who are, perhaps in some respects the most conservative and most inclined "to stick by the past" of any other set of manufacturers.

In 1882 there were in operation in France 515 beet-sugar factories. Of these 102 employed the process of diffusion. This rapid growth shows that the process is meeting in practice the theoretical advantages claimed for it.

I have not at my disposal statistics of the proportion of diffusion to press factories in other portions of Europe, but I am told that it is even greater than in France.

DIFFUSION APPLIED TO TROPICAL CANE.

In 1866, two years after Robert's success at Seelowitz, Mr. Minchin applied the diffusion process to sugar cane at Aska, province of

Five hundred and sixty-nine acres of cane, 28,051 pounds, at 7 to 8° Beaumé. Total amount of cane rolled, 15,961,384 pounds. Result obtained, 440 hogsheads at 1,150 pounds each. Total amount of sugar, 506,500 pounds; 1,000 barrels of molasses, at 43 gallons, 12 pounds per gallon, equal to 516,000 pounds. Sugar and molasses, total 1,022,500 pounds. The production of saccharine matter was 6.40 per cent. of the cane worked. Now, if the result obtained had been the same as that by diffusion 10.67 per cent. (from very inferior and deteriorated cane, the juice of which weighed only 6.66 Beaumé), the result would have been: sugar and molasses, total, 1,703,079 pounds, which is a surplus gained of 680,579 pounds.

To sum up, if the cane on Messrs. McCall's plantation had been worked by diffusion, and would have had only the same weight of Beaumé, 6.66, and had deteriorated besides, the result obtained would have been 293 hogsheads of sugar and 665 barrels of molasses, more than was obtained under the old process.

Colonel Amedée Bringier stated that he had chosen the finest cane on his place in order to test as exactly as possible how much could be obtained by one of the best mills in the State, and one of the most economically conducted sugar houses.

Fifty-one acres, at 57,794 pounds per acre, are 2,947,500 pounds; the cane juice weighed 8° Beaumé.

Production of sugar	pounds..	135,272
Production of molasses	do....	74,976
Total green sugar		210,248

Or 7.13 per cent. of saccharine matter to cane worked.

The great preponderance of sugar over molasses in this result is due, first, to the good condition of the cane; secondly, and principally, to superior handling and working of the cane juice after leaving the rollers.

Assuming he had obtained the result gained by the diffusion process, he would have had 314,498 pounds of sugar and molasses, which is a surplus over this result of 104,250 pounds; or, calculated in the same proportion as his relative quantities of sugar and molasses—total surplus sugar, 67,364 pounds; also, surplus molasses, 36,866 pounds

I also give here as a matter of special interest the report of Mr. Ludwig Kollmann, technical director of these experiments.

On this place the weight of the cane was carefully registered during our work; the quality of the cane was tested from time to time by passing a few canes through a small set of hand rollers and the juice weighed with a very delicate saccharometer. During this our first week's run the analyses of the mill juice and diffusion were as per table following.

To avoid all misapprehension it must not be forgotten that for every 100 gallons of mill juice we had 113 gallons of diffusion juice, which accounts for the apparent higher rating by saccharometer in mill than in diffusion juice:

Analyses of mill and diffusion juice.

Constituents.	Mill juice, specific gravity, 1.05746.	Diffusion juice, specific gravity, 1.04620.
	Per cent.	*Per cent.*
Crystallizable sugar	11.80	9.65
Glucose	1.68	1.38
Foreign substances	0.62	0.42
Saccharometer per cent., Balling	14.10	11.45

During the first week of our work there were 987,945 pounds of cane cut. This cane contained 90 per cent. of juice of which 83 were sent to the clarifiers: therefore obtained (calculating by the analyses above given):

	Per cent.
Crystallizable sugar	8.81
Glucose	1.25
Foreign substances	0.46

The loss of juice by clarification, skimmings, and sediments in sirup tanks amounts to about 6 per cent. on the weight of the juice, or 4.98 per cent. on the weight of the cane; therefore amount of juice really obtained in green sugar, 78 per cent. on the weight of the cane. Of this, 8.28 per cent. crystallizable sugar: 1.17 per cent., glucose: 0.43 per cent., foreign substances.

According to the established analysis every pound of foreign substances in cane juice prevents the same amount of sugar from crystallizing; and furthermore, through the influence of great heat, long continued in open kettles, a further amount of crystallizable sugar is converted into uncrystallizable sugar. To be on the safe side double the amount of glucose would represent the disturbing element in crystallization of the sugar contained in the diffusion juice, the perturbing action of the heat included.

Under these circumstances we ought to have had, in dry substances, 6.68 per cent. of crystallizable sugar, 3.20 per cent. of molasses.

To compare the above with the results obtained in our run, it will be necessary to reduce the amount of dry substances to the same basis.

	Per cent.
The amount of water in the sugar is	1.50
The amount of glucose and foreign substance	0.75
The amount of water in the molasses	20.00

This would give us 6.83 per cent. sugar, 3.78 per cent. molasses. Total, 10.61 per cent., against 10.37 per cent. actually obtained, showing a loss of 0.24 per cent., which has to be charged to profit and loss, attributable to want of control in the sugar-house.

Abstract from report of first week's run by diffusion, October 26 to October 31.

Sugar-cane worked up, 987,945 pounds.

Saccharometer:		
Density of mill juice	per cent.	14.10
Density of diffusion juice	do	11.45
Yield of undiluted juice on the weight of the cane	do	82.92
Sugar obtained:		
First product:		
Hogsheads		29
Pounds		35,595
Second product:		
Hogsheads		14.5
Pounds		16,111
Total in pounds		51,706
Molasses obtained:		
Barrels		100
Gallons		4,249
Pounds		50,778
Total sugar and molasses	pounds	102,484
Percentage of sugar on the weight of the cane		5.234
Percentage of molasses on the weight of the cane		5.139
Total percentage		10.37
Excess of diffusion products over mill products		42½ per cent.

The difference of 1.60 per cent. in the yield of sugar is due to the fact that our seconds did not have sufficient time to granulate and to settle, consequently much of the sugar of small grain passed through the centrifugals into the molasses, as proved by the analyses of the said molasses, showing far more per cent. of sugar than it ought to have had.

ANALYSIS OF MOLASSES.

	Per cent.
Dry substances by saccharometer	79.92
Water	20.08
Crystallizable sugar	63.82
Glucose	12.38
Foreign substances	3.72

It appears from the report made by Mr. E. D. Seghers that on the second run of diffusion we came very near obtaining the proper proportions of sugar and molasses.

To show the comparative yield of the mill and diffusion process, I give the table taken from Dr. Kratz's report:

Comparative table as to yield.

Process.	Duration.	Quantity cane consumed.	Products.		Per cent. sugar.	Per cent. molasses.	Total per cent.
			Sugar.	Molasses.			
	Days.	*Lbs.*	*Lbs.*	*Lbs.*			
Mill run	6	1, 986, 730	57, 743	43, 170	4. 164	3. 113	7. 277
Diff. 1st	6	987, 945	51, 706	50, 778	5. 234	5. 139	10. 373
Diff. 2nd	5	915, 515	54, 549	38, 752	5. 958	4. 233	10. 191

Process.	Surplus.			Cost of Manufacturing 1,000 pounds S. & M.	Against diffusion for 1,000 pounds S. & M.	Cost of 1, 000 pounds, including cane at $5.00 per ton.	Dry substances.	Dry substances.
	Sugar.	Molasses.	Total.					
	per cent.	*per cent.*	*per cent.*				*Lbs.*	*per cent.*
Mill run				$12 53		$46 88	90, 276	6. 51
Diff. 1st	25. 7	65. 1	42. 54	15 10	$2 57	39 20	90, 284	9. 14
Diff. 2d	43. 0	35. 98	40. 0	13 82	1 29	38 35	83, 764	9. 15

It will be seen by studying carefully the above table that owing to better manipulations on the part of all employés the relative quantity of crystallized sugar was very much increased in this run over the first run; and, financially considered, still better in comparison to mill run than our first run had been.

The total percentage of sugar and molasses in this run appears to be less than in the first, but in reality it is about the same, because it must be remembered that sugar contains from 1 to 3 per cent. of water, and molasses from 20 to 25 per cent.; and in the above figures this water is "counted in," as it always is in commerce.

In spite of this most pronounced success of the diffusion process, it has not been introduced into Louisiana, and, so far as I know, has not extended beyond these original experiments. I append a letter which I sent to Mr. R. Sieg, of New Orleans, whom I have to thank for many favors in the preparation of this report, and his answer thereto:

DEAR SIR: I desire to thank you for copies of the "Sucrerie Indigéne," containing articles by M. Riffard on the diffusion process applied to sugar-cane in Aska.

If you have leisure and inclination, will you kindly answer the following questions:

1. Has the diffusion process been tried in Louisiana any further than indicated in Dr. Kratz's report?
2. How many factories in the State are now using this process?
3. How do you explain the indifference with which the planters generally regard the process?

With your permission I desire to publish the answers which you may give. I will return the copies of the "Sucrerie" as soon as I have done with them.

Respectfully,

H. W. WILEY,
Chemist.

R. SIEG, 26 *North Charles Street, New Orleans, La.*

NEW ORLEANS, *December* 15, 1883.

DEAR SIR: Before replying to your questions in detail you will permit me to give you a short outline of the situation of the sugar industry in Louisiana, as we found it in 1873, when we introduced the diffusion process in this State.

We were then still sharing the common belief of our planters, that they could and did, with their more powerful mills at least, extract from 70 to 72 pounds of juice out of every 100 pounds of cane. We only hoped to increase this, by diffusion, to 84 to 85 pounds, so that by adopting the process our planters should gain about 20 per cent.

You may therefore judge how great must have been our surprise when, by the use of scales, by the measuring of the juice, and by the usual polariscopic tests, we ascertained beyond a doubt that only a very few mills in this country did extract more than 55 to 58 pounds of juice; that instead of obtaining only 20 per cent. more juice by diffusion, the yield was really increased from 40 to 50 per cent., and that this juice, in spite of the various defects in our primitive machinery, with its unavoidable irregularities and delays, had rather gained than lost in purity.

The discovery of these important facts made, of course, a deep impression upon our planters, and if our apparatus and some of its accessories had been as perfect as they should have been, and as inexpensive as they could be made at present, diffusion would have superseded every other means of extracting the juice from the cane, just as it has done this now in the modern beet-sugar industry.

Unfortunately, the first apparatus which we imported from Europe had been the one used by Mr. J. Robert, the inventor, and his father before him, in their original experiments, and it was handed over to us by the latter, as if for the purpose of getting rid of it. Of course, after using it in our first short trial, we, too, concluded that it was utterly useless for the diffusion process in general, and its application to cane in particular.

Subsequently our mechanics tried their skill upon the improvement of the apparatus, designing one, which in some respects was perhaps a trifle better; in other respects, however, even less good than the first one had been.

We only gained one point with it; through the reduction of its dimensions the apparatus worked faster. But the much desired and promised economics in labor as well as in cost of construction were really not attained. Consequently, when our sugar planters inspected our work in 1874-'75 they readily jumped at the conclusion that a superior and more reasonable apparatus could not be devised, and these two objections were for a time at least fatal to the process. And then the same mechanics who at the beginning had helped to advance the cause of diffusion, having lost their pecuniary interest in it, joined the opposition from rival inventors to pull it down.

Strangely enough, the same observation has recently been made regarding one of the greatest concerns of Paris, which was criticised for having done a similar service to the sugar manufacturers of their country, by influencing them to use some costly patent presses; and to this circumstance as much as to any other the inferiority of the French sugar industry of to-day was rightly or wrongly principally attributed.

Another objection was made also, viz: That diffusion would give our planters such longer be seen, except in some of the most superannuated and poorly arranged sugar factories of Europe or in the antiquated sugar-houses of tropical countries.

In this respect the sugar-planters of the Hawaiian Archipelago are setting us an example worthy of imitation, for notwithstanding their great natural advantages, they seem to be ever anxious and ready to take hold of every improvement or progress which the cane-sugar industry has been or is on the point of making. I was therefore not much astonished to learn that the other day these planters had listened with particular attention and favor to a proposition submitted to them with a view of inducing their Government to appropriate $50,000 or $60,000 for the importation from Europe of a diffusion apparatus and other machinery necessary to the establishment of an experimental station, at which the process could receive a complete and thoroughly scientific test. Considering the great influence which these sugar-planters have, and the great services which their industry has rendered to their Government, it could scarcely deny them a favor so insignificant in comparison to the object in view.

But the planters of the Sandwich Islands are not alone in their endeavor to advance their industry as much as they can; the sugar-planters of Cuba are also earnestly thinking of improving especially their present unsatisfactory methods of juice-extraction, and from information lately received I believe that they too intend to give the process a fair trial next season. The necessity for these improvements is imposed upon them by the recent abolition of slavery, by the growing scarcity of labor, and by the nevertheless declining value of their products. It seems therefore quite certain that our planters also can no longer trust in the natural or artificial advantages of their position, and that, on the contrary, they ought to use every available means to economize in their expenditures, in their raw material and labor, so that they too may be able to resist any further encroachments upon the value of their crops and productions.

Most respectfully,

R. SIEG.

Prof. H. W. Wiley, *Washington, D. C.*

EXPERIMENTS MADE IN GUADALOUPE.

The next account which I find of experiments made with diffusion on sugar-cane is in a communication by M. Edmond Riffard to the "Sucrerie Indigène," published in the numbers for 19th and 26th of June and 18th of September, 1883. According to the observations of Riffard on tropical cane, the mean content of sugar is 15.3 per cent. in the juice, or 13.77 per cent. of the total weight of cane. There is expressed by double milling, with intermediate saturation of the first bagasse with hot water, an amount of saccharine matter represented by the following figures:

Per cent. juice expressed by first mill	60
Per cent. juice expressed by second mill	25

equal to 11 per cent. of normal juice. Total per cent. normal juice expressed, 71. Each 100 kilograms of cane, therefore, furnished 71 kilograms of juice, or $\frac{71 \times 15.3}{100} = 10.86$ kilograms of sugar. But 100 kilograms of cane contain $\frac{100 \times 13.77}{100} = 13.77$ kilograms of sugar. The sugar lost in the bagasse, therefore, is $13.77 - 10.86 = 2.89$ kilograms.

The total amount of sugar lost in the molasses is .75 kilogram; and in manufacture, .86 kilogram; and total sugar obtained, 9.25 kilograms.

This is certainly a favorable showing for mill work, and yet these are the results which led Riffard to make the experiments with diffusion.

In sorghum the best yields of sugar heretofore obtained on weight of cane have been 3 to 3.5 per cent. We would certainly be satisfied if this could be raised to 9.25.

DIFFUSION OF THE BAGASSE.

Riffard made some experiments with the bagasse; although I think it hardly proper to call them experiments with *diffusion.* When the cells are crushed, as in the bagasse, *maceration* is a more appropriate term.

The bagasse was chopped in a straw cutter and placed in diffusion cells holding 73 kilograms each. In all, 950 kilograms were used. The amount of diffusion juice obtained was 3.8 hectoliters; of wash water, 5.4 hectoliters.

Reduced to the basis of the density of the juice as it comes from the mill, this gave 53.93 per cent. of the weight of the bagasse, or 21.57 per cent. of the weight of the cane.

It is thus seen that by double milling 71 per cent. of juice is obtained and 21.57 by diffusion of the bagasse, giving a total content of 92.57 per cent. of juice in the cane.

The following is the summary of the experiments made with bagasse.

1. The bagasse must be cut into small pieces before it is subjected to diffusion.
2. In this condition the bagasse readily submits to the process.
3. The products of diffusion calculated as normal mill juice amount to about 22 per cent. of the weight of the cane.
4. With rapid work the purity of the juice will be equal, if not superior, to that of the second milling.
5. The system of the "long battery" is the one to be adopted.

These are valuable results. They show that it would pay to institute the process of diffusion in connection with milling.

One of the great objections to the introduction of diffusion has always been that it would result in the practical loss of the milling machinery already in operation. But from these experiments it appears that the process can be established in connection with milling, and then when the mills break or wear out the diffusion machinery will be ready to take their place.

DIFFUSION OF CANE.

M. Riffard also reports some experiments of diffusion applied to cane, from which I will make a few quotations. The canes were cut into rondelles, having a thickness of 2 or 3 millimeters. In the first experiment 725 kilograms of rondelles were subjected to diffusion. The volume of juice obtained was 4.40 hectoliters, sp. gr., 1.056; of wash water, 4.60 hectoliters, sp. gr., 1.025; equal to 2 hectoliters, sp. gr., 1.056; total volume of juice, 6.40 hectoliters.

Calculated for normal mill juice, this gave a yield of 84.9 per cent.

Two other experiments were made.

A comparison of these with the product obtained from milling the same cane is seen in the following table. The diffusion juice is calculated in terms of normal mill juice.

Comparison of juices of diffusion and milling.	Mill juices.			Diffusion juices.		
	First milling.	Second milling.	Mean.	A.	B.	C.
Density	1.063	1.046	1.056	1.066	1.060	1.064
Sugar, per hectoliter	14.74	10.97	13.30	15.82	14.38	15.10
Uncrystallizable sugar	1.04	0.67	0.89	0.85	0.92	1.09
Purity coefficient	87.6	87.3	87.4	88.43	88.29	87.00

It is seen by the above that the process of diffusion has notably increased the yield of sugar, although it is evident that the extraction was not complete. Only 84.9 per cent. of juice was obtained, and 92—84.9=7.1 per cent. remained in the pulp.

FURTHER EXPERIMENTS AT ASKA.

From the report of Mr. Riffard I also learn something further of the success of the Minchin works, already mentioned, at Aska.

ANALYSIS OF ASKA CANES.

A mean of the analysis of various parts of the cane gives the following as the composition of the entire stalk:

Cellulose	8.20
Water	76.94
Sugar and soluble matters	14.86

The canes show a considerable difference in composition in the upper, lower, and middle thirds. This is shown in the following analysis:

An average lot of canes.

Constituents.	.608 meter of the top.	.608 meter of the center.	.608 meter of the butt.
Cellulose	7.63	8.47	8.30
Sugar	10.63	13.31	13.37
Glucose	2.64	1.51	1.54
Salts	3.07	0.259	0.233
Water	78.334	75.612	76.122
Undetermined	0.459	0.839	0.455

In Louisiana canes the difference is even more striking, but it does not seem to appear in sorghum canes. From the Agricultural Report for 1881 and 1882, page 463, I quote a table and paragraph illustrative of the above:

Table showing relative value of different parts of sugar-cane stalk.

Constituents.	Butt.	Middle.	Top.
Sucrose........per cent..	15.36	12.95	3.21
Glucose........do....	.75	1.42	3.68
Solids........do....	.24	.68	2.23
Available sugar........do....	14.37	10.85	-2.70
Specific gravity........	1.068	1.061	1.038

From the above results there would seem to be in the immature sugar-cane top a close resemblance to the immature stalks of sorghum, and yet the analogy ceases as soon as the sorghums have attained a full maturity, for, as the results of very many analyses show, there is practically no difference in the juice from the upper or lower half of the sorghum stalks.

From his experiments Mr. Minchin is led to believe that—

A capacity of from 25 to 30 hectoliters appears to us the most favorable for the cells, their emptying and cleaning are thus rendered easy, the cane yielding its juice with ease. The temperature is to be maintained at 90°–95° C. We are assured by analysis that no inversion takes place in these conditions of temperature.

In the two experiments below, performed with great care, the temperature of the entering juice, measured at the calorisator, was 90° C. (mean).

Number of cells.	Duration of process.				Density of the outflowing juice at 28° C.	
	A.		B.		A.	B.
	H.	*M.*	*H.*	*M.*		
1........		25		15	1.020	1.020
2........		15		15	1.037	1.032
3........		10		10	1.050	1.047
4........		15		10	1.055	1.055
5........		10		20	1.056	1.063
6........		10		10	1.066	1.068
	1	25	1	20		

It is seen that at the sixth cell the maximum density corresponds to that of normal juice. All stoppage of the work of the battery, the aeration of the juices, their cooling, are to be avoided. Juices which are not obtained by lime defecation, whatever be their origin, are changed at the temperature of the air; the lime with which they are commonly alkalised is an illusory preservative. If the battery is operated in the condition of temperature indicated, the juice will flow out with a light amber tint and with a remarkable limpidity. Any lack of transparency indicates a lowness of the temperature of extraction.

Such has been the history, as far as I am able to trace it, of the application of diffusion to tropical cane. The process has not spread with the rapidity which characterized its introduction into the sugar beet industry and which its merits warrant. But what has been done is of the utmost value for comparison with the experiments I have made in its application to sorghum, and which I will now proceed to give in detail.

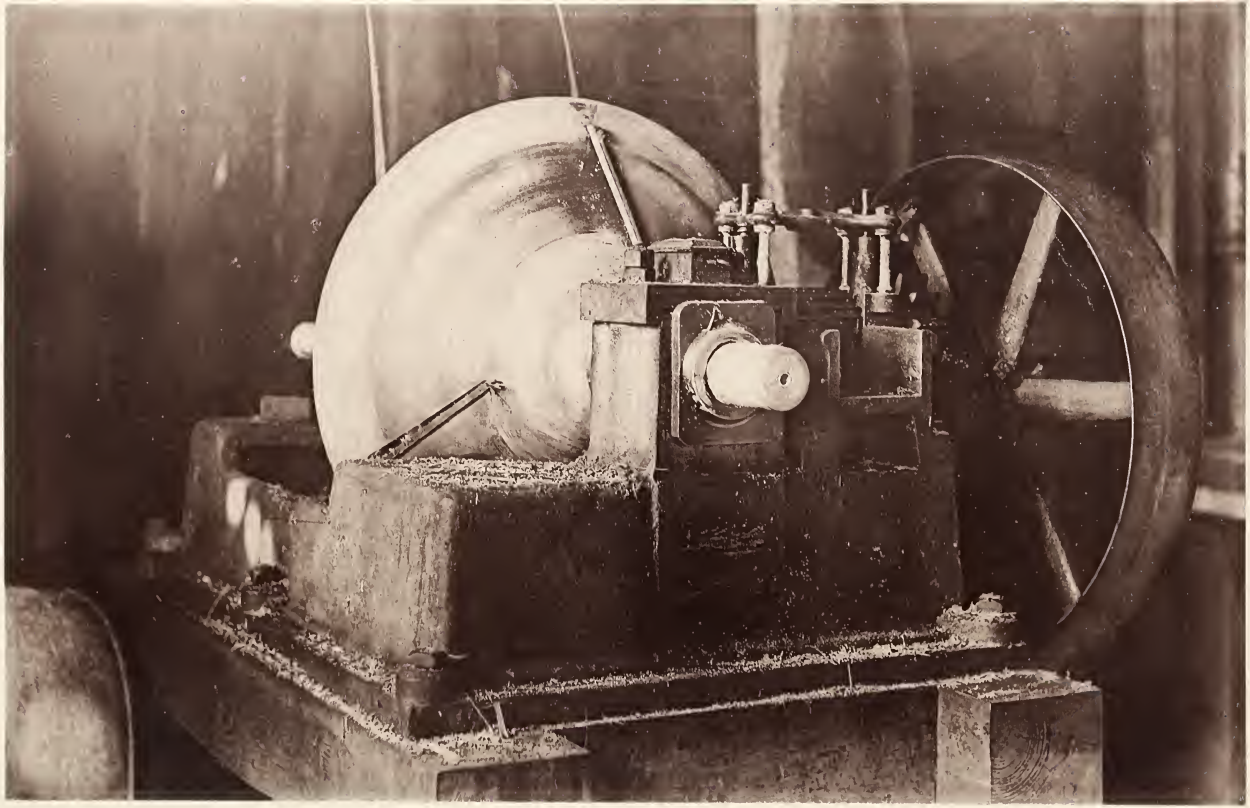

Fig. (1).—THE EXPERIMENTAL CANE CUTTER.

DIFFUSION APPLIED TO SORGHUM.

The following were the problems proposed in the experiments:

1. To devise suitable apparatus.
2. To determine percentage of saccharine matter extracted.
3. To determine percentage of saccharine matter left in chips and waste water.
4. To compare diffusion juices with mill juices from [illegible] canes.
5. To establish best proportion of water to use.
6. To determine influence of time and temperature on percentage of sugar extracted and its properties.

APPARATUS.

The apparatus for the experiments in diffusion I had constructed by the Colwell Iron Company of New York. It consists of two parts, viz, the cane cutter and the diffusion battery.

THE CANE CUTTER.

This machine consists of a cast iron disk, conical in shape and carrying three knives shaped like the bit of a carpenter's plane.

The canes are delivered to the cutter by a forced feed set to move at such a rate that the canes are advanced from one-eighth to one-sixteenth of an inch during each third of a revolution of the disk. The canes being fed parallel to the axis of the machine, are struck by the knives in the conical disk at an angle of about 35°, i. e., the angle of inclination of the cutting surface of the disk to the axis. The disk revolves 500 to 800 times per minute. Each revolution represents three-eighths or three-sixteenths inch of canes cut. The rate of movement of the canes therefore is 187 to 300 inches per minute. The knives are easily detached when dull, and sharp ones put in their places. I find that the knives should be ground twice a day and sharpened with an oilstone every two hours.

The dimensions of the experimental cutter are—

Diameter of disk	feet	2
Thickness of disk	inches	1½
Angle of inclination of disk		35°
Diameter of shaft	inches	2½
Length of shaft	feet	4
Diameter of pulley	inches	12
Capacity for ten hours	tons	3½ to 4

The disk was covered by a hood so that the chips could not be thrown into the room. These were received by a box underneath. This apparatus at first gave some trouble on account of the feed, which was not properly arranged. When this was adjusted, however, the machine worked well.

A cane cutter properly constructed will always have an advantage over a cane mill, viz, it will be difficult to break it or get it out of order. On the other hand, cane mills are a constant source of trouble, and often by sudden breakage entail great loss on the manufacturer.

Fig. (1).—THE EXPERIMENTAL CANE CUTTER.

DIFFUSION APPLIED TO SORGHUM.

The following were the problems proposed in the experiments:

1. To devise suitable apparatus.
2. To determine percentage of saccharine matter extracted.
3. To determine percentage of saccharine matter left in pulp and waste water.
4. To compare diffusion juices with mill juices from same kind of cane.
5. To establish best proportion of water to use.
6. To determine influence of time and temperature on percentage of juice extracted and its properties.

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The dimensions of the experimental cutter are—

Diameter of disk	feet..	2
Thickness of disk	inches..	1¾
Angle of inclination of disk		35°
Diameter of shaft	inches..	2½
Length of shaft	feet..	4
Diameter of pulley	inches..	13
Capacity for ten hours	tons..	3.5 to 4

The disk was covered by a hood so that the chips could not be thrown into the room. These were received by a box underneath. This apparatus at first gave some trouble on account of the feed, which was not properly arranged. When this was adjusted, however, the machine worked well.

A cane cutter properly constructed will always have an advantage over a cane mill, viz, it will be difficult to break it or get it out of order. On the other hand, cane mills are a constant source of trouble, and often by untimely breaking entail great loss on the manufacturer.

Instead of having the knives shaped as in the cutter just described, I think it would be better to have them thinner. The thick knife tends to break the chip into several pieces in lines parallel to the axis of the cane. I am not prepared to say that this is a disadvantage. It certainly exposes a greater surface to the action of the diffusion juices. It may, however, by the rupture of a greater number of cells, tend to defeat the idea of diffusion, which is percolation through unbroken membranes. The substance of the cane being much more brittle than that of the beet, it will be found quite impracticable to secure for the diffusion process chips as perfect as the *cossettes* and *schnitzel* of the French and German factories.

CAPACITY OF CUTTERS.

It may be objected to the method under discussion that it would not be practicable to construct machines to work on a large scale, say from two to four hundred tons of cane per day. Judging from my experience with the small mill and the experiments carried on in Louisiana, to which reference has already been made, I would say that such an objection is untenable. For equal weights of cane a cutter will, if properly constructed, be lighter and require less power to run it than a mill. I think that all cane-workers will be glad to give a fair hearing to the claims of a machine which will relieve them from the worry and expense of the choking, breaking, and creaking of the mills.

DIFFUSION BATTERY.

This machine consists of eleven cells arranged in such a way that a liquid from any one of them can be transferred to another, either from the top or bottom of the cell, at will. The cells are 30 inches long, 12 inches in diameter, and hold about 10 gallons. On one side is the system of tubes and valves by which the process of filling and emptying is carried on. On top of the cells are the openings through which they are filled with the freshly-cut chips. Each cell ends below in an opening set obliquely to its axis, through which the exhausted chips are discharged.

On the side opposite the feed-valves is found the steam supply by which the cells or the liquid contained in them can be heated either from above or below. This heating should take place in separate compartments, which in large apparatus are called calorisators. The water is forced through the cells by the ordinary pressure of the Washington water-works, which here is scarcely equal to the pressure of two atmospheres. The water as it flows to the cells passes through a heater, where it can be brought to any desired temperature.

MANIPULATION.

The first cell having been filled with chips and the openings all closed except the air-valve at the top, water from the heater at a temperature of 60° C. (or other desired degree) is admitted through the bottom of the cell until it begins to flow out through the air-valve at the top. This vent is now closed, and the valves changed so that the

Fig. [illegible].—THE DIFFUSION BATTERY.

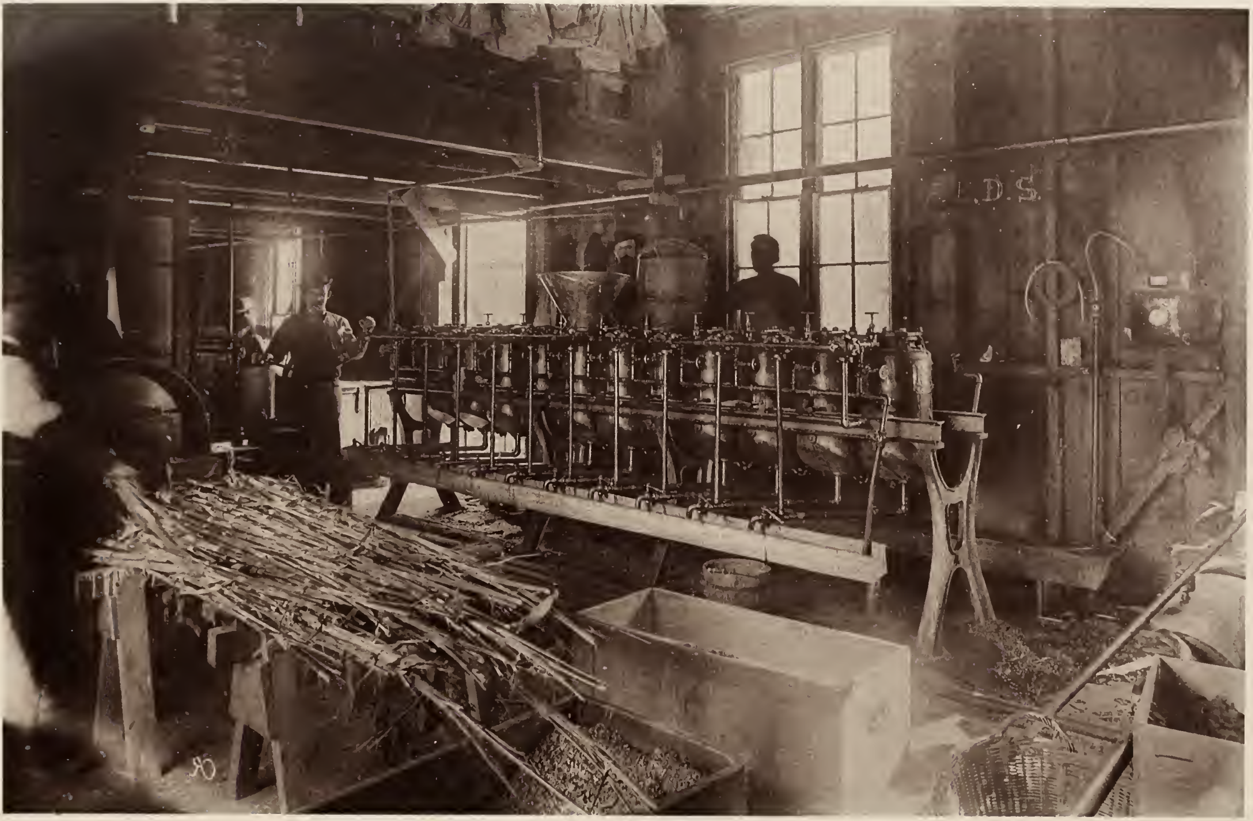

Fig (2).—THE DIFFUSION BATTERY.

water enters from the top of the first cell. The second cell is now filled with the liquid from the first, which has meanwhile become charged with all the sugar it is capable of taking from the first chips. The valves are so arranged that the liquid from the first cell is forced out by the fresh water entering from above and into the second cell from below until this is filled. The third cell is now brought into action in the same way, the fresh water entering through the top of the first cell, the valves having been changed for the second cell so that the liquid from the first flows in at the top of the second, forcing its contents out and up through the third cell. This process continues until nine cells have been filled.

By this time the chips in the first cell, having been treated with nine successive portions of fresh water, have lost all but the merest trace of their sugar. This cell is therefore shut off from all the others, the fresh water is turned on to the second cell, and while the tenth cell is filling the first one is emptied of its exausted chips. The fresh water is next turned on the third cell, while the eleventh one is filling; meanwhile the first cell is prepared for the second charge of fresh chips, and the process now goes on regularly, nine cells being always in use, and two being filled or emptied.

RESULTS.

Careful analyses were made during the process of the experiments to determine the completeness of the extraction and the character and quality of the diffusion juices, and to compare them with the juices of the same canes obtained from the mill.

The diffusion cells held 18.2 kilograms (40 pounds) of chips. This quantity was weighed and put in each cell. The cell after being filled with chipswould still hold nearly 22 kilograms of water (48 pounds). The exhausted chips were found to have increased in weight, so that each cell-full weighed nearly 22 kilograms. The charge and discharge of the cell therefore are represented by the following table:

	Kilograms.
Weight of fresh chips taken	18
Weight of exhausted chips	22
Weight of diffusion juice drawn off	22
Weight of waste water	22
Per cent. diffusion juice to weight of chips	122

Each 100 parts chips gave of juice 122 parts.

INCREASE IN VOLUME OF DIFFUSION JUICE OVER MILL JUICE.

A large number of experiments has shown that the total content of juice in the cane is 89 per cent. (nearly). Of this amount about 85 are extracted by diffusion. Whence it follows that a mill which would extract as much of the saccharine matter as diffusion would give, for each 100 parts cane 85 parts; by diffusion, for 100 parts cane, 122 parts; or, 100 parts mill juice are represented by 143.5 parts diffusion juice.

It thus appears that the amount of evaporation required for diffusion juice is a little less than one-half more than that required for mill juice. Nearly 180 experiments made this year with diffusion have shown that only about one-half of one per cent. of sucrose is lost in the pulp and waste water. Let us take, therefore, for an illustration, a cane containing 12 per cent. sugar:

100 kilograms of this cane contain of sugar	kilograms	12
Loss, .5 per cent	do	2.5
Sugar obtained by diffusion	do	9.5
Per cent. sugar obtained by diffusion		80
100 kilograms of cane contain of juice	kilograms	89
Obtained by mill	do	50
Per cent. obtained by mill		55
Per cent. sugar obtained by mill		6.6
Per cent. sugar obtained by diffusion		9.5
Per cent. sugar gained by diffusion		2.9
Per cent. sugar gained to total sugar		24

Thus allowing a liberal loss of sugar in diffusion, and taking a fair average result of single milling, we find a gain of 24 per cent. in sugar.

I will compare this theoretical result with one obtained in actual practice:

Experiments in diffusion run of November 9, 1883.*

Cane diffused	kilograms	990.00
Juice obtained	do	1210.00
Waste water	do	1210.00
Pulp	do	1210.00
Per cent. of sucrose in diffusion juice		4.73
Per cent of other sugars in diffusion juice		2.12
Per cent. of total sugars in diffusion juice		6.85
Weight of total sugars obtained	kilograms	82.89
Per cent. of sucrose in pulp		.27
Per cent. of other sugar in pulp		.06
Per cent. of sucrose in waste water		.03
Per cent. of other sugar in waste water		.07
Per cent. of total sugar in pulp and waste water		.43
Weight of total sugar lost	kilograms	5.32
Total sugars in 990 kilograms cane	do	88.21
Per cent. of total sugars obtained		93.97
Per cent. of total sugars lost		6.03

It is thus seen that out of 100 parts of sugar in the cane on November 9, 93.97 parts were obtained.

Compare with this the result of the (theoretical mill work)—

	Kilograms.
Weight of juice from 990 kilograms (50 per cent.)	495.00
Weight of juice not obtained	386.00
Per cent. of juice (and saccharine matters) extracted	57.3
Total sugar in 990 kilograms cane	88.21

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* Boiled to semi-sirup on this date and to melada several days later.

	Kilograms.
Of which obtained by the mill	54.85
Total sugar lost	33.36
Per cent. of total sugar obtained	62.39
Per cent. of total sugar lost	37.61
Per cent. of total sugar lost by diffusion	6.03
Gain by diffusion ... per cent.	31.58

It appears from the data of the analytical work that the gain in sugar by diffusion over ordinary milling is from 25 to 30 per cent., and over double milling from 15 to 20 per cent. Until November 14 I was unable to use the small vacuum pan which I had procured for these experiments, and therefore the results in *masse cuite* and sugar could not be kept separate.

On November 14 I obtained the following data:

Analyses.

Diffusion juice November 14:	
Specific gravity	1.0406
Sucrose	6.04
Other sugars	2.16
Purity	67.5
Total solids	9.05
Mill juice, same cane and date:	
Specific gravity	1.065
Sucrose	9.95
Other sugars	3.29
Purity	64.4
Total solids	15.13
Melada obtained, 196.4 kilograms (by diffusion):	
Per cent. sucrose	52.50
Per cent. other sugars	20.85
Weight of chips diffused ... kilograms	1,596
Weight of juice obtained ... do	1,929
Weight of sucrose in *masse cuite* ... do	103
Percentage of *masse cuite* to cane	12.28

LOSS OF SUGAR.

The pulp from the 1,596 kilograms of cane weighed 1,929 kilograms. It contained .12 per cent. sucrose, and .06 per cent. other sugars.

Then 1,929 × .0018 = 3.47 kilograms of sugar lost in pulp.

The waste water from the above weighed 1,929 kilograms. It contained .01 per cent. of sucrose and .07 per cent. other sugars.

Then 1,929 × .0008 = 1.54 kilograms of sugar lost in waste water.

Total loss in both, 5.01 kilograms.

The *masse cuite* obtained above is well crystallized, but the crystals are so small and the proportion of gum so great that I have not been able to purge it in the centrifugal. I shall allow it to stand for some time in a warm room and make another trial.*

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* Later attempts to purge these sugars were attended with little success. The poor quality of the cane, however, does not render the experiment any the less instructive.

Another trial was made on Tuesday, November 20, of the same kind of cane as above (Link's Hybrid), which had been frozen on the preceding Thursday, and left since that time lying in the yard.

Run of November 20, 1883.

	Kilograms.
Weight of chips diffused	1447.8
Weight of juice obtained	1738
Weight of pulp obtained	1738
Weight of waste water obtained	1738
Weight of semi-sirup	276.3
Weight of *masse cuite*	157.8

Analyses November 20, 1883.

Samples analyzed.	Sucrose.	Other sugars.
Chips	7.68	3.38
Mill juice	9.58	3.70
Diffusion juice	5.63	2.50
Pulp (exhausted chips)	0.10	0.06
Waste water	0.026	0.027
Semi-sirup	28.94	12.58
Masse cuite	48.83	22.15

RESULTS.

Percentage of *masse cuite* to cane diffused=10.9

Total weight of sugar in diffusion juice was 1,738 × .0813=141.30 kilograms.

Total weight of sugar in pulp was 1,738 × .0016=2.77 kilograms.

Total weight of sugar in waste water was 1,738 × .00053=0.92 kilogram.

Total weight of sugar in cane=141.30 + 2.76 + .92=144.98 kilograms.

Total loss in diffusion 3.69 kilograms.

Per cent. of loss in diffusion 3.04.

Total weight of sugar in semi-sirup was 276.3 × .4152=114.72 kilograms.

Loss during evaporation to semi-sirup was 141.30—114.72=26.58 kilograms.

This loss was due to wastage, scum, and especially to the sediment and gum separated during defecation and which could not be filtered.

MASSE CUITE.

Total weight of *masse cuite*, 157.8 kilograms.

Total weight of sugar in *masse cuite* = 157.8×.7079=112.0 kilograms.

Loss in reduction from semi-sirup to *masse cuite* =114.72—112.01=2.71.

The total loss of sugar during evaporation was 2.99 + 2.71=5.70 kilograms, or nearly 5 per cent. of the weight of the *masse cuite.* This practical result conforms to the experience of the beet sugar manufacturers, who always allow for 5 per cent. loss in boiling.

THE EXPERIMENTS IN DETAIL.

The experiments with diffusion were begun on the 16th of October and finished on the 20th of November, 1883. In all, twenty-three days of ten working hours each were devoted to these experiments. Analyses were made each day of the diffusion and mill juices, the pulp, and the waste water. On eleven days two analyses, as indicated above, were made.

Results of the analytical work.

TABLE I.—DIFFUSION JUICES.

No. of analysis.	Date.	Specific gravity.	Total solids.	Total sugars.	Sucrose by direct polarization.	Sucrose by double polarization.	Coefficient of purity.	Average of other sugars.	Per cent. of ash.	Per cent. of nitrogen.	Per cent. of albumen.	Per cent. of nitrogen as amids.
			Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*		*Pr. ct.*				
1	Oct. 16	1.0439	7.850	7.38	3.20	3.50	44.6	3.88	.3303	.0240	.1500	34.2
3	Oct. 19	1.0234	10.647	9.10	....	4.58	43.0	4.52	.3322	.0152	.0950	92.8
5	Oct. 20	1.0350	8.400	8.18	3.75	4.27	50.8	3.91	.2806	....	....	......
12	Oct. 22	1.0372	8.775	7.53	5.55	5.28	60.2	2.25	.4416	.0293	.1831	92.6
13	Oct. 23	1.0341	8.101	6.86	4.70	4.43	54.7	2.43	.4023	.0247	.1544	86.7
19	Oct. 25	1.0341	8.150	7.48	4.80	5.11	62.7	2.37	.3182	.0260	.1625	75.0
23	Oct. 25	1.0338	8.125	7.46	4.95	5.00	60.9	2.46	.3173	....	....	......
27	Oct. 26	1.0383	8.800	8.09	5.75	5.60	63.6	2.49	.3535	....	....	......
32	Oct. 27	1.0303	7.012	6.52	4.35	4.43	63.2	2.09	.3019	....	....	......
36	Oct. 27	1.0283	6.875	6.30	4.20	....	61.1	2.10	.2645	....	....	......
48	Oct. 30	1.0305	7.270	6.89	5.30	5.21	71.7	1.68	.3105	....	....	......
52	Oct. 30	1.0330	7.675	6.72	5.15	5.05	65.8	1.67	.3320	....	....	......
60	Oct. 31	1.0290	6.781	6.34	4.55	4.49	66.2	1.85	.3343	....	....	......
61	Oct. 31	1.0258	6.000	5.67	4.05	3.98	66.3	1.69	.2847	....	....	......
64	Nov. 1	1.0339	7.841	7.01	5.15	5.14	65.6	1.87	.4207	....	....	......
69	Nov. 2	1.0309	7.375	6.66	4.65	4.76	64.5	1.90	.3890	....	....	......
74	Nov. 2	1.0305	7.300	7.17	4.80	5.08	69.6	2.09	.2966	....	....	......
76	Nov. 3	1.0268	6.119	4.95	....	3.41	55.7	1.54	.4032	....	....	......
85	Nov. 5	1.0352	8.209	7.84	5.25	5.52	67.2	2.32	.4009	.0228	.1425	......
91	Nov. 5	1.0296	7.075	6.62	4.35	4.53	64.0	2.09	.2875	....	....	......
96	Nov. 6	1.0327	7.675	6.63	5.15	5.25	68.4	1.38	.5781	.0120	.0750	......
102	Nov. 7	1.0270	6.425	5.65	3.90	4.02	62.6	1.63	....	.0195	.1219	......
108	Nov. 8	1.0311	7.375	7.11	4.85	5.02	68.1	2.09	....	.0303	.1894	......
112	Nov. 8	1.0330	7.723	7.49	5.55	5.61	72.6	1.88	....	.0302	.1888	......
118	Nov. 9	1.0298	7.125	6.75	4.50	4.72	66.2	2.03	....	.0229	.1431	......
121	Nov. 9	1.0304	7.325	6.91	4.65	4.75	64.9	2.16	....	.0314	.1963	......
126	Nov. 10	1.0353	7.780	7.68	2.30	3.51	45.1	4.17	....	.0301	.1881	......
131	Nov. 10	1.0363	8.050	8.73	2.55	3.63	45.1	5.10	....	.0282	.1763	......
141	Nov. 12	1.0473	11.060	9.90	4.10	5.32	48.1	4.58	....	.0596	.3728	......
146	Nov. 13	1.0369	8.540	7.66	5.65	5.83	68.3	1.83	.3916	.0474	.2963	......
150	Nov. 13	1.0379	8.550	7.95	5.80	6.00	70.2	1.95	.4413	.0312	.1950	......
155	Nov. 14	1.0366	8.300	7.87	5.20	5.46	65.8	2.41	....	.0355	.2219	......
158	Nov. 14	1.0372	8.756	7.65	5.20	5.46	62.4	2.19	....	.0390	.2438	......
163	Nov. 15	1.0441	10.100	9.03	6.85	6.81	67.4	2.22	....	.0471	.2944	......
166	Nov. 15	1.0406	9.275	8.22	6.45	6.40	69.0	1.82	....	.0365	.2281	......
173	Nov. 20	1.0355	8.500	7.56	4.85	5.17	60.8	2.39	....	.0390	.2438	......
177	Nov. 20	1.0420	9.852	8.73	5.90	6.09	61.8	2.64	....	.0453	.2831	......
	Av	1.0340	8.021	7.36	4.80	4.95	61.8	2.42	.3571	.0316	.1976	73.3

Results of the analytical work—Continued.

TABLE II.—MILL JUICES.

No. of analysis.	Date.	Specific gravity.	Total solids.	Total sugars.	Sucrose by direct polarization.	Sucrose by double polarization.	Coefficient of purity.	Average of other sugars.	Per cent. of ash.	Per cent. of nitrogen.	Per cent. of albumen.	Per cent. of nitrogen as amids.
			Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*		*Pr. ct.*				
2	Oct. 16	1.0701	14.500	13.46	6.20	7.32	50.5	6.16	.3934	.0482	.3013	......
4	Oct. 19	1.0624	14.960	12.62	....	5.81	38.83	6.81	.4432	....	....	......
9	Oct. 22	1.0552	12.754	10.67	7.60	7.64	52.10	3.03	.6289	.0401	.2506	80.1
14	Oct. 23	1.0514	12.069	10.38	6.00	6.34	52.50	4.04	.5279	.0343	.2138	. ....
18	Oct. 25	1.0647	15.039	13.09	9.45	9.45	62.8	3.64	.4865	.0533	.3331	73.4
26	Oct. 26	1.0609	14.009	12.71	8.55	8.72	62.2	3.99	.4355	....	....	......
33	Oct. 27	1.0581	13.450	12.53	6.90	7.91	58.8	4.62	.4622	....	....	......
41	Oct. 29	1.0591	13.447	12.04	7.60	7.92	58.9	4.12	.4428	....	....	......
46	Oct. 30	1.0701	15.643	13.53	10.37	10.24	65.5	3.29	.5467	....	....	......
55	Oct. 31	1.0723	16.691	14.20	11.10	11.00	65.9	3.20	.6248	....	....	......
62	Nov. 1	1.0696	16.337	14.24	11.20	11.18	68.4	3.06	.6086	....	....	......
68	Nov. 2	1.0694	15.881	14.05	9.35	9.79	61.6	4.26	.5975	....	....	......
77	Nov. 3	1.0616	16.325	14.13	....	12.00	73.5	2.13	.8666	....	....	......
83	Nov. 5	1.0603	14.200	13.13	7.80	8.66	60.9	4.47	.4772	.0434	.2713	......
94	Nov. 6	1.0672	15.495	13.27	10.85	10.64	68.6	2.63	.8246	.0472	.2950	......
100	Nov. 7	1.0672	15.743	14.43	10.25	10.55	67.6	3.88	....	.0420	.2625	......
106	Nov. 8	1.0629	14.700	13.18	9.35	9.58	65.2	3.60	....	.0463	.2894	......
116	Nov. 9	1.0638	15.200	13.61	9.40	9.94	65.4	3.67	....	.0380	.2375	......
125	Nov. 10	1.0603	13.500	13.44	5.00	6.61	48.9	6.83	....	.0487	.3044	......
137	Nov. 12	1.0648	14.850	13.51	4.35	6.57	44.2	6.94	.6028	.0451	.2819	......
145	Nov. 13	1.0633	14.900	12.93	9.20	9.64	64.7	3.29	....	.0357	.2231	......
154	Nov. 14	1.0611	14.475	12.70	8.90	9.21	63.6	3.49	....	.0622	.3888	......
162	Nov. 15	1.0692	15.772	13.78	10.30	10.69	67.7	3.09	....	.0378	.2363	......
172	Nov. 20	1.0680	15.500	13.28	9.10	9.58	61.8	3.70	....	.0786	.4913	......
	Av....	1.0639	14.810	13.12	8.58	9.04	60.4	4.08	.5606	.0467	.2921	76.7

TABLE III.—WASTE WATERS.

No of analysis.	Date.	Total sugars.	Sucrose by direct polarization	Average of other sugars.
		Per cent.	*Per cent.*	*Per cent.*
6*	Oct. 20	.743	.260	.483
10	Oct. 22	.083	.000	.083
16*	Oct. 23	.966	.760	.206
20*	Oct. 25	.838	.430	.408
24*	Oct. 25	.321	.083	.238
28	Oct. 26	.138	.071	.067
34	Oct. 27	.133	.071	.062
39	Oct. 27	.045	.016	.029
43	Oct. 29	.124	.051	.073
49	Oct. 30	.134	.077	.057
53	Oct. 30	.127	.071	.056
57	Oct. 30	.439	.311	.128
66	Nov. 1	.165	.071	.094
71	Nov. 2	.217	.110	.107
81	Nov. 3	.138	trace	.138
86	Nov. 5	.361	.194	.167
97	Nov. 6	.136	.071	.065
103	Nov. 7	.107	.038	.069
109	Nov. 8	.248	.123	.125
113	Nov. 8	.035	trace	.035
119	Nov. 9	.103	.039	.064
122	Nov. 9	.072	.019	.053
128	Nov. 10	.166	.032	.134
132	Nov. 10	.100	.000	.100
139	Nov. 12	.112	.032	.080
142	Nov. 12	.058	.006	.052
148	Nov. 13	.074	.019	.055
151	Nov. 13	.057	.012	.045
156	Nov. 14	.004	.000	.004
159	Nov. 14	.080	.000	.080
164	Nov. 15	.060	.025	.037
167	Nov. 15	.032	.000	.032
175	Nov. 20	.028	.000	.028
178	Nov. 20	.050	.025	.025
	Av	.191	.094	.102

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* The large amount of sugar in these waste waters was due to imperfect working of the stop-cocks at the first. Aside from these and one or two other numbers, the quantity of sugar lost in the waste

TABLE IV.—PULPS

No. of analysis.	Date.	Total sugars.	Sucrose by direct polarization.	Average of other sugars.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
7	Oct. 20	.189	.00	.189	.1980
11	Oct. 20	.272	.25	.022	.3560
17	Oct. 23	1.038	.52	.518	.3860
21	Oct. 25	1.268	.85	.748	.1820
25	Oct. 25	1.235	.56	.675	.3860
29	Oct. 26	.403	.30	.103	.2300
35	Oct. 27	.480	.33	.150	.2133
38	Oct. 27	.283	.20	.046	.2350
44	Oct. 29	.605	.50	.105	.2666
50	Oct. 30	.875	.72	.155	.2220
54	Oct. 30	.693	.40	.293	.2240
59	Oct. 30	1.691	1.30	.391	.3120
67	Nov. 1	.727	.48	.247	.2283
73	Nov. 2	.593	.44	.153	.1940
80	Nov. 3	.017	Trace.	.017	.2840
87	Nov. 5	1.290	1.00	.290	.3320
92	Nov. 5	1.340	1.08	.260	.2960
98	Nov. 6	.401	.25	.150	.3640
104	Nov. 7	.416	.30	.116	.2680
110	Nov. 8	1.852	1.48	.372	....
114	Nov. 8	.162	.16	.002	....
120	Nov. 9	.318	.25	.068	....
123	Nov. 9	.365	.30	.065	....
129	Nov. 10	.567	.24	.327	....
133	Nov. 10	.204	.15	.027	....
140	Nov. 12	.256	.20	.056	....
143	Nov. 12	.130	.12	.010	....
149	Nov. 13	.010	Trace.	.010	....
152	Nov. 13	.020	Trace.	.020	....
157	Nov. 14	.062	Trace.	.062	....
160	Nov. 14	....	Trace.	Trace.	....
165	Nov. 15	.181	.15	.035	....
168	Nov. 15	.010	Trace.	.010	....
176	Nov. 20	.175	.10	.075	.2660
179	Nov. 20	.040	Trace.	.040	.3028
	Av......	.534	.468	.159	.2736

TABLE V.—ANALYSES OF DIFFUSION, SEMI-SIRUP.

No. of analysis.	Date.	Specific gravity.	Total solids.	Total sugar.	Sucrose by direct polarization.	Sucrose by double polarization.	Average of other sugars.	Coefficient of purity.	Ash.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
8	Oct. 22	1.2149	45.01	37.39	16.0	18.49	18.90	40.8	1.6729
15	Oct. 22	1.2275	45.80	39.94	27.9	27.03	11.91	61.2	2.2700
22	Oct. 22	1.1982	41.32	36.20	23.0	23.83	12.37	56.6	1.6783
40	Oct. 29	1.1933	40.42	36.03	23.2	23.81	12.22	58.9	1.6316
45	Oct. 30	1.2774	54.49	41.26	23.0	22.59	18.67	41.4	2.2750
51	Oct. 30	1.2314	47.20	42.41	27.5	27.80	14.61	58.8	1.8300
56	Oct. 31	1.2221	45.60	40.17	29.1	29.00	11.17	63.5	1.8616
63	Nov. 1	1.2465	49.20	42.65	29.8	30.30	12.35	61.5	2.4816
70	Nov. 2	1.2693	53.58	45.57	30.2	30.20	15.37	58.2	2.7200
78	Nov. 3	1.2578	50.29	43.64	....	29.16	14.48	57.9	2.7766
82	Nov. 5	1.2944	57.33	45.93	32.8	33.29	12.64	58.0	.4733
93	Nov. 6	1.2569	46.08	40.41	26.0	27.42	12.99	59.5	2.4852
99	Nov. 7	1.2200	44.91	39.79	27.8	29.22	10.57	65.0	....
105	Nov. 8	1.2336	46.93	42.61	29.1	30.81	11.80	65.6	....
115	Nov. 9	1.2262	44.81	40.85	26.0	27.52	13.33	61.4	....
124	Nov. 10	1.1906	38.16	33.65	21.8	23.17	10.48	60.7	....
130	Nov. 10	1.2424	47.50	41.62	27.1	28.51	13.11	60.0	....
135	Nov. 12	1.2250	43.50	39.72	12.4	17.29	22.43	39.5	....
144	Nov. 13	1.2685	53.39	44.90	17.4	23.49	21.41	45.7	1.7180
153	Nov. 14	1.2204	44.58	38.22	26.6	27.93	10.29	62.6	....
161	Nov. 15	1.2266	43.36	40.06	27.3	28.69	11.37	66.1	....
169	Nov. 15	1.2298	46.23	41.22	28.6	29.64	11.58	64.1	....
180	Nov. 20	1.2295	46.99	41.52	27.5	28.94	12.58	61.5	....
	Av......	1.2348	46.725	40.68	25.4	26.92	13.77	57.8	1.9903

CONCLUSIONS.

The experiments in diffusion I freely admit are far from being satisfactory. I think, however, that a great deal can be learned from acquiring a practical idea of the nature of the defects in any new process. I consider the following to be the chief faults in the experiments made:

(1.) I aimed to secure a diffusion juice of about the same density as the diffusion juice from the beet as obtained in the European factories. I am convinced now that this was a mistake. If a mill juice shows a density of 1.062, I think a diffusion juice should have one of not less than 1.050. In fact I think the volume of the diffusion juice should represent a weight not greater than that of the canes diffused. The average ratio of the weight of the cane to that of the diffusion juice in the experiments was not far from 100 : 125. It is true that in localities where coal can be obtained for $20 a carload, a very dilute juice is not so objectionable, from a merely economical view. On the other hand, if the juice is first to be concentrated in open pans, its dilution becomes a very serious matter. The liability to inversion on long boiling is too well known to need any additional emphasis here. But there are many localities where coal is dear and evaporating capacity limited. In such places the production of a juice as dilute as that represented in the foregoing tables, would be a fatal objection to the process.

I confess I do not see how such dense juices are obtained as those mentioned in the experiments in Guadaloupe. In quite a number of my experiments I allowed the water to remain ten minutes in contact with each cell of chips, or ninety minutes in all for the contents of each cell. Yet the highest specific gravity obtained even by this method was 1.0473 as shown in Analysis 141, Table I. There are three factors in the problem of the application of diffusion to sorghum, which demand a more careful study, viz, (*a*) time, (*b*) temperature, and (*c*) pressure.

(*a*.) I think for nine cells two hours at a mean of 60° C. would not be more than sufficient to secure the mean density desired.

I am convinced now that I did not allow the diffusion juices to remain long enough in contact with the chips. The chief objection to allowing a longer time for diffusion is found in the tendency to fermentation, which these dilute juices possess in the highest degree. This objection I consider to be fully met by my uniform practice of introducing into each fresh charge of warm water some antiseptic like lime bisulphite or carbolic acid. Another objection is found in the increased time required to complete the extraction. This, however, can be met by increasing the size of the diffusers.

(*b*) There is no doubt of the fact that osmosis in vegetable cells will take place more rapidly as the temperature of the ambient fluid rises Thus a more rapid extraction of the sugar will take place if the temperature be kept at a higher degree. On the other hand as water approaches a boiling point it dissolves any starch granules which the cells may contain, and transforms the insoluble pectose into soluble pectine, and brings into solution any other difficultly soluble bodies which the chips may contain. I have noticed moreover at these high temperatures that the outflowing juice is highly colored, and has a peculiar odor which indicates the solution of some odoriferous bodies not dissolved by a colder liquid.

(*c*) This method works well, and has none of the disadvantages which characterize the others. I have noticed that when by means of a system of steam-pipes with which my battery was supplied I produced a pressure of three or four atmospheres for a few moments on each cell, the degree of exhaustion was much greater than when only the ordinary pressure of the water, amounting to less than two atmospheres, was employed. The sorghum-cane is more compact than tropical cane, and will require more care in diffusion.*

Pressure appears to me to be the most promising aid in securing a greater density. But I would not hesitate to combine all three of these proposed methods of securing a heavier product, in case any one alone should fail. I shall give them all a thorough trial, in case Congress sees fit to make an appropriation to continue experiments in this direction.

The best way of all to have secured a denser juice would have been to use a less quantity of water. I am of the opinion, from a study of the analytical data, that the proper weight of water to use would be equal to the weight of the chips diffused. In this way, if all the other conditions of manipulation were properly attended to, a juice of 1.05 specific gravity would be secured from canes giving a mill juice of 1.06.

(2.) The discrepancy which exists between the data furnished by the analyses and those obtained by the weight of the cane diffused and juices obtained is to me the most unsatisfactory result of the work done.

It appears from the analyses that the total sugars left in the chips and lost in the waste water are—

Pulp	sucrose	.468	Other sugars	.159
Waste water	"	.094	Other sugars	.102
Sum		.572		.271

In all, .743 per cent. The total sugars in the canes worked was 13.12—(13.12 × .11) = 11.68 per cent., and the per cent. of sugar extracted (by analysis) is (11.68—.743) ÷ 11.68 = 93.64. According to the record of weight and measurement kept at the sugar-house, the total percentage of sugar extracted was about 85. In the two days' run, when the juice obtained was boiled separately in a small vacuum pan to *masse cuite* the weight of the melada obtained was, in round numbers, 11 per cent. of the cane. This shows that the results of the analyses were borne out by the amount of melada obtained.

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* This is shown by the slow increase in density of the diffusion juices, and also by some mill experiments, in which I found that Louisiana canes would yield about 4 per cent. more juice than sorghum, under the same conditions.

I think it would be fair in giving a summary of the work to base it on a mean of these two sets of results. I prefer, however, to take the lower numbers as a basis. I think much injury may be done by generalizing on a few good results and taking no account of those of an inferior order.

SUCCESS.

Respecting the success which attended the experiments the following statements may be made:

(1.) The extraction of at least 85 per cent. of the total sugars present was secured. In many of the experiments, as will be seen by consulting the table, scarcely a trace of sugar could be detected in the exhausted chips.

(2.) The production of a quantity of melada represented by from 10.9 to 12.28 per cent. of the weight of the cane diffused.

This was secured with a cane in which the total sugars did not exceed 11.68 per cent. The percentage of melada by this process will be found just about equal to the per cent. of total sugars in the cane.

It ought to be greater with a more perfect extraction, but I am speaking only of results actually obtained.

This yield is just about double that obtained by the large factories at Rio Grande, Champaign, and other places.

(3.) The production of a juice of great purity, which lends itself easily to processes of depuration.

I consider the experiments, however, to have their chief value in the fact that they will call the attention of cane-growers to the advantages which a rational system of diffusion will have over pressure in the extraction of the saccharine matter.

I hope to be able at the end of another season to report further progress in this interesting problem.

In the present condition of the sorghum-sugar industry, in which it has alike to be protected from the overzeal of its friends and the opposition of its enemies, the process of diffusion offers the most promising outlook for success. It therefore seems the duty of this Division to make a more practical test of this process and on a larger scale.

Since your accession to office you have done much to place this industry on a firm footing, and therefore I need only suggest the direction of investigations to secure your most hearty co-operation. I have already, in my general report to you, indicated the amount of the appropriation needed to carry out these investigations, and I close by hoping that the liberality of Congress will be as large as your recommendations and the necessities of this great industry.

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